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PATENT

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For: REFRIGERATION APPARATUS CONSTRUCTING METHOD, AND REFRIGERATION APPARATUS (AS AMENDED)	:

SUBMISSION OF TRANSLATION

Assistant Commissioner of Patents
Washington, DC 20231

Sir:

Applicants submit herewith an English translation of Japanese Patent Application No. 2003-175928 and 2003-361828 including 33 pages and 12 sheets of drawing.

The attached document represents a true and complete English translation of Japanese Patent Application No. 2003-175928 and 2003-361828.

Respectfully submitted,

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SPECIFICATION

FREEZING DEVICE CONSTRUCTION METHOD AND FREEZING DEVICE

FIELD OF THE INVENTION

The present invention relates to a refrigeration apparatus constructing method and a refrigeration apparatus, and more particularly relates to a refrigeration apparatus constructing method, and a refrigeration apparatus comprising: a heat source unit comprising a compressor and a heat source side heat exchanger; a utilization unit comprising a utilization side heat exchanger; and a refrigerant connecting pipe that connects the heat source unit and the utilization unit.

BACKGROUND ART

An example of a conventional refrigeration apparatus is a separate type air conditioner. An air conditioner of this type principally comprises: a heat source unit comprising a compressor and a heat source side heat exchanger; a utilization unit comprising a utilization side heat exchanger; and a liquid refrigerant connecting pipe and a gas refrigerant connecting pipe that connect these units.

In such an air conditioner, the series of construction steps, from the equipment installation, piping, and wiring work to the startup of operation principally comprises the following four processes:

(1) installing equipment, piping, and wiring work;

(2) drawing a vacuum in the refrigerant connecting pipe;

(3) filling supplementary refrigerant (performed as needed); and

(4) starting operation.

In the construction of an air conditioner as mentioned above, the work of drawing a vacuum in the refrigerant connecting pipe is important in order to prevent: the release of the refrigerant into the atmosphere; the deterioration of the refrigerant and the refrigerator oil due to residual oxygen gas; a rise in the operating pressure due to the noncondensable gas, whose principal component is an air component such as oxygen gas and nitrogen gas; and the like; however, there is a problem because it is necessary to perform troublesome work like connecting the vacuum pump to the liquid refrigerant connecting pipe and the gas refrigerant connecting pipe.

To solve this problem, an air conditioner has been proposed that, by connecting a gas separation apparatus filled with an adsorbent to a refrigerant circuit and circulating the refrigerant, adsorbs and eliminates from the refrigerant the noncondensable gas remaining inside the refrigerant connecting pipe after the equipment installation, piping, and wiring

work. It is possible to omit the vacuum drawing work wherein a vacuum pump is used, thereby simplifying the construction of the air conditioner (e.g., refer to Patent Document 1). However, with this air conditioner, a large amount of the adsorbent is needed to enable the adsorption of as much of the noncondensable gas contained in the refrigerant as possible, which consequently increases the size of the overall apparatus, and actually makes it problematic to mount on the refrigeration apparatus.

In addition, an air conditioner has been proposed that: connects a jig comprising a separation membrane to the refrigerant circuit; fills the entire refrigerant circuit beforehand with a refrigerant sealed in the heat source unit; mixes the refrigerant and the noncondensable gas that remained inside the refrigerant connecting pipe after equipment installation, piping, and wiring work; subsequently supplies the separation membrane without raising the pressure of the refrigerant and the noncondensable gas mixture; and separates and eliminates the noncondensable gas. Thereby, it is possible to omit the vacuum drawing work wherein a vacuum pump is used, thereby simplifying the construction of the air conditioner (e.g., refer to Patent Document 2). However, with this air conditioner, the pressure differential cannot be increased between the separation membrane upstream side (i.e., inside the refrigerant circuit) and downstream side (i.e., outside the refrigerant circuit), which is a problem because of the low efficiency by which the separation membrane separates the noncondensable gas.

<PATENT DOCUMENT 1>

Published Unexamined Utility Model Application H05-69571

<PATENT DOCUMENT 2>

Japanese Published Patent Application No. H10-213363

DISCLOSURE OF THE INVENTION

It is an object of the present invention to improve the efficiency of separating a noncondensable gas with a separation membrane in a refrigeration apparatus constituted, for the purpose of omitting the vacuum drawing work, so that, by using a separation membrane, it can separate and eliminate the noncondensable gas, in a state mixed with a refrigerant inside a refrigerant circuit, that was left inside the refrigerant connecting pipe during on-site construction.

A refrigeration apparatus constructing method according to the first invention is a method of constructing a refrigeration apparatus, comprising: a heat source unit comprising a compressor and a heat source side heat exchanger; a utilization unit comprising a utilization side heat exchanger; and a liquid refrigerant connecting pipe that connects the heat source unit and the utilization unit; the method comprising the steps of an equipment installing step

and a noncondensable gas discharging step. The equipment installing step constitutes a refrigerant circuit by installing the heat source unit and the utilization unit, and connecting the refrigerant connecting pipe. The noncondensable gas discharging step operates the compressor to circulate a refrigerant inside the refrigerant circuit, uses a membrane to separate a noncondensable gas remaining inside the refrigerant connecting pipe from the refrigerant flowing between the heat source side heat exchanger and the utilization side heat exchanger, and discharges the noncondensable gas out of the refrigerant circuit.

With this method of constructing the refrigeration apparatus, the equipment arranging step constitutes the refrigerant circuit by installing the heat source unit and the utilization unit and connecting the refrigerant connecting pipe; subsequently, the noncondensable gas discharging step raises the pressure of the refrigerant and the noncondensable gas, flowing between the heat source side heat exchanger and the utilization side heat exchanger, by operating the compressor and circulating the noncondensable gas remaining inside the refrigerant connecting pipe along with the refrigerant inside the refrigerant circuit, and using a membrane to separate from the noncondensable gas-containing refrigerant, whose pressure has been increased, the noncondensable gas and discharging it out of the refrigerant circuit. Thus, by operating the compressor and circulating the refrigerant, the pressure differential between the upstream side (i.e., inside the refrigerant circuit) and the downstream side (i.e., outside of the refrigerant circuit) of the separation membrane used in membrane separation can be increased, and the efficiency of separating the noncondensable gas in the separation membrane can consequently be improved.

A refrigeration apparatus constructing method according to the second invention is a method of constructing a refrigeration apparatus, comprising: a heat source unit comprising a compressor and a heat source side heat exchanger; a utilization unit comprising a utilization side heat exchanger; and a liquid refrigerant connecting pipe that connects the heat source unit and the utilization unit; the method comprising the steps of a refrigerant circuit constituting step and a noncondensable gas discharging step. The refrigerant circuit constituting step constitutes a refrigerant circuit by connecting the heat source unit and the utilization unit via the refrigerant connecting pipe. The noncondensable gas discharging step operates the compressor to circulate a refrigerant inside the refrigerant circuit, uses a separation membrane to separate a noncondensable gas remaining inside the refrigerant connecting pipe from the refrigerant flowing between the heat source side heat exchanger and the utilization side heat exchanger, and discharges the noncondensable gas out of the refrigerant circuit.

With this method of constructing the refrigeration apparatus, the refrigerant circuit constituting step connects the heat source unit and the utilization unit via the refrigerant connecting pipe; subsequently, the noncondensable gas discharging step raises the pressure of the refrigerant and the noncondensable gas, flowing between the heat source side heat exchanger and the utilization side heat exchanger, by operating the compressor and circulating the noncondensable gas remaining inside the refrigerant connecting pipe along with the refrigerant inside the refrigerant circuit, and using a separation membrane to separate the noncondensable gas from the noncondensable gas-containing refrigerant, whose pressure has been increased, and discharging it out of the refrigerant circuit. Thus, by operating the compressor and circulating the refrigerant, the pressure differential between the upstream side (i.e., inside the refrigerant circuit) and the downstream side (i.e., outside of the refrigerant circuit) of the separation membrane used in membrane separation can be increased, and the efficiency of separating the noncondensable gas in the separation membrane can consequently be improved.

A refrigeration apparatus constructing method according to the third invention is a refrigeration apparatus constructing method as recited in the first or second invention, wherein, in the noncondensable gas discharging step, the refrigerant flowing between the heat source side heat exchanger and the utilization side heat exchanger is vapor-liquid separated into liquid refrigerant and the noncondensable gas-containing gas refrigerant, and the noncondensable gas is subsequently separated from the vapor-liquid separated gas refrigerant.

With this method of constructing the refrigeration apparatus, the refrigerant flowing between the heat source side heat exchanger and the utilization side heat exchanger is gas-liquid separated into noncondensable gas-containing gas refrigerant and liquid refrigerant, and the amount of gas processed by membrane separation is reduced, thereby enabling a reduction in the size of a gas separation apparatus.

A refrigeration apparatus constructing method according to the fourth invention is a refrigeration apparatus constructing method as recited in the third invention, wherein in the noncondensable gas discharging step, the separated noncondensable gas is released into the atmosphere.

Because a vessel, and the like, that accumulates the separated noncondensable gas is no longer necessary with this method of constructing the refrigeration apparatus, the size of the gas separation apparatus that performs membrane separation can be further reduced.

A refrigeration apparatus constructing method according to the fifth invention is a refrigeration apparatus constructing method as recited in any one invention of the first

invention through the fourth invention, further comprising: a seal testing step that, before the noncondensable gas discharging step, performs a seal test on the refrigerant connecting pipe; and a sealed gas releasing step that, after the seal testing step, reduces pressure by releasing a sealed gas inside the refrigerant connecting pipe into the atmosphere.

With this method of constructing the refrigeration apparatus, a seal test is performed on the refrigerant connecting pipe using the sealed gas, such as nitrogen gas, and the sealed gas is released into the atmosphere; consequently, the amount of oxygen gas remaining inside the refrigerant connecting pipe after these steps is reduced. Thereby, because the amount of oxygen gas circulating inside the refrigerant circuit together with the refrigerant can be reduced, the risk of a problem like deterioration of the refrigerant or the refrigerator oil can be eliminated.

The refrigeration apparatus according to the sixth invention is a refrigeration apparatus that constitutes a refrigerant circuit, wherein a heat source unit comprising a compressor and a heat source side heat exchanger, and a utilization unit comprising a utilization side heat exchanger, are connected via a refrigerant connecting pipe, comprising: a gas separation apparatus comprising a separation membrane connected to a liquid side refrigerant circuit that connects the heat source side heat exchanger and the utilization side heat exchanger, and that is capable of separating from the refrigerant and discharging out of the refrigerant circuit the noncondensable gas remaining inside the refrigerant connecting pipe by operating the compressor and circulating the refrigerant inside the refrigerant circuit.

With this refrigeration apparatus, the heat source unit and the utilization unit are connected via the refrigerant connecting pipe; subsequently, the pressure of the refrigerant and the noncondensable gas, flowing between the heat source side heat exchanger and the utilization side heat exchanger, is raised by operating the compressor and circulating the noncondensable gas, whose principal component is an air component such as oxygen gas and nitrogen gas, remaining inside the refrigerant connecting pipe along with the refrigerant inside the refrigerant circuit; a separation apparatus having a separation membrane is used to separate the noncondensable gas from the noncondensable gas-containing refrigerant, whose pressure has been increased; and the noncondensable gas is then discharged out of the refrigerant circuit. Thereby, by operating the compressor and circulating the refrigerant, the pressure differential between the upstream side (i.e., inside the refrigerant circuit) and the downstream side (i.e., outside of the refrigerant circuit) of the separation membrane increases, and the efficiency of separating the noncondensable gas in the separation membrane can consequently be improved.

The refrigeration apparatus according to the seventh invention is a refrigeration apparatus as recited in the sixth invention, wherein the liquid side refrigerant circuit further comprises a receiver capable of accumulating the refrigerant flowing between the heat source side heat exchanger and the utilization side heat exchanger. The gas separation apparatus is connected to the receiver, and separates the noncondensable gas contained in the gas refrigerant accumulated in the upper part of the receiver.

With this refrigeration apparatus, the gas separation apparatus is connected to the receiver provided in the liquid side refrigerant circuit, the refrigerant flowing through the liquid side refrigerant circuit is gas-liquid separated into noncondensable gas-containing gas refrigerant and liquid refrigerant, the amount of processed gas is reduced, and the gas separation apparatus can subsequently separate the noncondensable gas, consequently reducing the size of the gas separation apparatus.

The refrigeration apparatus according to the eighth invention is a refrigeration apparatus as recited in the seventh invention, wherein the gas separation apparatus further comprises a discharge valve for releasing the separated noncondensable gas into the atmosphere.

Because a vessel, and the like, that accumulates the separated noncondensable gas is no longer necessary with this refrigeration apparatus, the size of the gas separation apparatus can be further reduced.

BRIEF EXPLANATION OF DRAWINGS

FIG. 1 is a schematic view of a refrigerant circuit of an air conditioner that serves as a refrigeration apparatus according to the first embodiment of the present invention.

FIG. 2 depicts the schematic structure of a receiver and a gas separation apparatus of the air conditioner according to the first embodiment.

FIG. 3 lists the molecular weight data for various gases.

FIG. 4 is a schematic view of the refrigerant circuit of the air conditioner according to a first modified example of the first embodiment.

FIG. 5 is a schematic view of the refrigerant circuit of the air conditioner according to a second modified example of the first embodiment.

FIG. 6 depicts the schematic structure of the receiver and the gas separation apparatus of the air conditioner according to the second modified example of the first embodiment.

FIG. 7 is a schematic view of the refrigerant circuit of the air conditioner that serves as the refrigeration apparatus according to the second embodiment of the present invention.

FIG. 8 is a schematic view of the refrigerant circuit of the air conditioner according to a first modified example of the second embodiment.

FIG. 9 is a schematic view of the refrigerant circuit of the air conditioner that serves as the refrigeration apparatus according to the third embodiment of the present invention.

FIG. 10 depicts the schematic structure of a separation membrane apparatus of the air conditioner according to the third embodiment.

FIG. 11 is a schematic view of the refrigerant circuit of the air conditioner according to a first modified example of the third embodiment.

FIG. 12 is a schematic view of the refrigerant circuit of the air conditioner according to a second modified example of the third embodiment.

FIG. 13 is a schematic view of the refrigerant circuit of the air conditioner that serves as the refrigeration apparatus according to the fourth embodiment of the present invention.

PREFERRED EMBODIMENTS

The following explains the embodiments of a refrigeration apparatus constructing method and refrigeration apparatus according to the present invention, based on the drawings.

<FIRST EMBODIMENT>

(1) CONSTITUTION OF AN AIR CONDITIONER

FIG. 1 is a schematic view of a refrigerant circuit of an air conditioner 1 as one example of a refrigeration apparatus according to the first embodiment of the present invention. The air conditioner 1 in the present embodiment is a cooling dedicated air conditioner, and comprises a heat source unit 2, a utilization unit 5, and a liquid refrigerant connecting pipe 6 and a gas refrigerant connecting pipe 7 that connect the heat source unit 2 and the utilization unit 5.

The utilization unit 5 principally comprises a utilization side heat exchanger 51.

The utilization side heat exchanger 51 is equipment capable of cooling the air inside a room by a refrigerant that flows therewithin.

The heat source unit 2 principally comprises a compressor 21, a heat source side heat exchanger 23, a heat source side expansion valve 26, a liquid side gate valve 27, and a gas side gate valve 28.

The compressor 21 is equipment for compressing the gas refrigerant that is taken in.

The heat source side heat exchanger 23 is equipment capable of condensing the refrigerant using air or water as a heat source. The heat source side expansion valve 26 is connected on the exit side of the heat source side heat exchanger 23 for regulating the refrigerant pressure, the refrigerant flow, and the like. The liquid side gate valve 27 and the

gas side gate valve 28 are connected to the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7, respectively.

The liquid refrigerant connecting pipe 6 is connected between the entrance side of the utilization side heat exchanger 51 of the utilization unit 5 and the exit side of the heat source side heat exchanger 23 of the heat source unit 2. The gas refrigerant connecting pipe 7 is connected between the exit side of the utilization side heat exchanger 51 of the utilization unit 5 and the intake side of the compressor 21 of the heat source unit 2. The liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7 are, for example, the refrigerant connecting pipes constructed on-site when newly constructing an air conditioner 1, or the refrigerant connecting pipes diverted from an existing air conditioner when replacing just the heat source unit 2 and the utilization unit 5.

Here, the refrigerant circuit that ranges from the utilization side heat exchanger 51 to the heat source side heat exchanger 23, including the liquid refrigerant connecting pipe 6, the liquid side gate valve 27, and the heat source side expansion valve 26, is a liquid side refrigerant circuit 11. In addition, the refrigerant circuit that ranges from the utilization side heat exchanger 51 to the heat source side heat exchanger 23, including the gas refrigerant connecting pipe 7, the gas side gate valve 28, and the compressor 21, is a gas side refrigerant circuit 12. Namely, a refrigerant circuit 10 of the air conditioner 1 comprises the liquid side refrigerant circuit 11 and the gas side refrigerant circuit 12.

In the present embodiment, the air conditioner 1 further comprises a receiver 25 provided in the liquid side refrigerant circuit 11. More specifically, it is provided between the heat source side heat exchanger 23 and the heat source side expansion valve 26. The receiver 25 is capable of accumulating the refrigerant condensed by the heat source side heat exchanger 23. Furthermore, the liquid refrigerant condensed by the heat source side heat exchanger 23 flows outward from the lower part of the receiver 25, and is sent to the heat source side expansion valve 26. Consequently, the gas refrigerant not condensed by the heat source side heat exchanger 23 is gas-liquid separated inside the receiver 25, and accumulates in the upper part of the receiver 25 (refer to FIG. 2).

The air conditioner 1 further comprises a gas separation apparatus 31 connected to the liquid side refrigerant circuit 11. In the present embodiment, the gas separation apparatus 31 principally comprises a separation membrane apparatus 34.

By operating the compressor 21 and circulating the refrigerant inside the refrigerant circuit 10, the separation membrane apparatus 34 can discharge from the refrigerant to outside of the refrigerant circuit 10 the noncondensable gas remaining in the liquid refrigerant

connecting pipe 6 and the gas refrigerant connecting pipe 7. Here, the noncondensable gas is a gas whose principal component is an air component, such as oxygen gas and nitrogen gas. Consequently, if the refrigerant is circulated inside the refrigerant circuit 10, it flows into the receiver 25 without being condensed in the heat source side heat exchanger 23, and accumulates along with the gas refrigerant in the upper part of the receiver 25.

In the present embodiment, the separation membrane apparatus 34 is equipment provided integrally with the upper part of the receiver 25, and, as depicted in FIG. 2, comprises: a container main body 34a wherein one part is in communication with the upper part of the receiver 25; a separation membrane 34b disposed so that it splits the space inside the container main body 34a into a space S_1 and a space S_2; and a discharge valve 34c connected to the space S_2.

The separation membrane 34b, which is called a porous membrane, is made of a material such as a polyimide membrane, a cellulose acetate membrane, a polysulfone membrane, and a carbon membrane, and has a function wherein water vapor, oxygen gas, nitrogen gas, and the like, which are components that have comparatively small molecular weights, permeate, but the gas refrigerant, which has a large molecular weight, does not. Here, the porous membrane has numerous extremely fine pores, and the gas inside these pores separate when passing through, depending on the speed differential, i.e., components having a small molecular diameter permeate, but components having a large molecular diameter do not. For example, because the molecular weights (more specifically, the molecular diameters) of the R22 and R134a, as well as the molecular weights of the R32 and R125 contained in the mixed refrigerants R407C and R410A, which are used as refrigerants in the air conditioner, are larger than the molecular weights (more specifically, the molecular diameters) of any of the water vapor, oxygen gas, and nitrogen gas, as depicted in FIG. 3, they can be separated by the separation membrane 34b. The space S_1 is in communication with the upper part of the receiver 25. The space S_2 is the space into which flows the air component that permeated the separation membrane 34b. The discharge valve 34c is provided for opening the space S_2 to the atmosphere, and is capable of releasing the air component (such as oxygen gas and nitrogen gas, which permeated the separation membrane 34b and flowed into the space S_2) from the space S_2 into the atmosphere.

(2) METHOD OF CONSTRUCTING THE AIR CONDITIONER

The following explains the method of constructing the air conditioner 1.

<EQUIPMENT INSTALLING STEP (REFRIGERANT CIRCUIT CONSTITUTING STEP)>

The air conditioner 1 and the refrigerant circuit 10 are constituted by first emplacing the newly equipped utilization unit 5 and the heat source unit 2, installing the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7, and connecting the utilization unit 5 and the heat source unit 2. At this point, the liquid side gate valve 27 and the gas side gate valve 28 of the newly equipped heat source unit 2 are shut off, and the refrigerant circuit of the heat source unit 2 is pre-filled with a predetermined amount of the refrigerant. Furthermore, the discharge valve 34c of the separation membrane apparatus 34 is shut off.

Furthermore, if replacing the utilization unit 5, the heat source unit 2, or both by diverting the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7 that constitute an existing air conditioner, then, in the procedure mentioned above, only the utilization unit 5 and the heat source unit 2 are newly emplaced.

<SEAL TESTING STEP>

A seal test is performed on the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7 after constituting the refrigerant circuit 10 of the air conditioner 1. However, if the utilization unit 5 is not provided with a gate valve, and the like, for the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7, then the seal test is performed on the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7 in a state connected to the utilization unit 5.

First, nitrogen gas is supplied as the seal test gas from a supply port (not shown), which is provided in the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7, and the like, to a seal test portion, which includes the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7, and the pressure of the seal test portion is then raised to the seal test pressure. Furthermore, after the supply of the nitrogen gas stops, it is verified whether the seal test portion holds the seal test pressure for the prescribed test time.

<SEALED GAS RELEASING STEP>

After the seal test has ended, the ambient gas (the sealed gas) in the seal test portion is released into the atmosphere to reduce the pressure in the seal test portion. At this point, because the ambient gas in the seal test portion contains a large amount of nitrogen gas that was used in the seal test, the greater part of the ambient gas in the seal test portion is substituted by nitrogen gas after being released into the atmosphere, thereby reducing the amount of oxygen gas. Additionally, to prevent the infiltration of air from outside of the refrigerant circuit 10 when performing the work of releasing the ambient gas into the

atmosphere, the pressure in the seal test portion, which includes the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7, is reduced to a pressure slightly higher than atmospheric pressure.

<NONCONDENSABLE GAS DISCHARGING STEP>

The liquid side gate valve 27 and the gas side gate valve 28 of the heat source unit 2 are opened, after the sealed gas has been released, creating a state wherein the refrigerant circuit of the utilization unit 5 and the refrigerant circuit of the heat source unit 2 are connected. Thereby, the refrigerant that was pre-filled in the heat source unit 2 is supplied to the entire refrigerant circuit 10. However, if the required refrigerant fill quantity is insufficient with just the amount of refrigerant pre-filled in the heat source unit 2, e.g., in the case wherein the refrigerant connecting pipes 6, 7 are long, then refrigerant can be externally supplemented and then filled as needed. Furthermore, if the heat source unit 2 is not pre-filled with refrigerant, then the entire amount of the refrigerant needed is externally filled. Thereby, the sealed gas (containing the noncondensable gas remaining in the utilization unit 5 if simultaneously performing the seal test on the utilization unit 5), which serves as the noncondensable gas remaining in the refrigerant connecting pipes 6, 7 after the sealed gas releasing step, is mixed with the refrigerant inside the refrigerant circuit 10.

In this circuit configuration, operation is performed by activating the compressor 21 and circulating the refrigerant inside the refrigerant circuit 10, the same as in normal operation. At this time, the opening of the heat source side expansion valve 26 is regulated to bring the pressure in the range from the discharge side of the compressor 21 to the heat source side expansion valve 26 of the liquid side refrigerant circuit 11 to the condensing pressure of the refrigerant. Namely, the pressure in the receiver 25 is raised to the condensing pressure of the refrigerant. Thereby, refrigerant in a saturated, gas-liquid mixed phase, which contains the noncondensable gas (the air component largely containing nitrogen gas) remaining in the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7 after releasing the sealed gas, flows into the receiver 25. The refrigerant that flows into the receiver 25 is gas-liquid separated into liquid refrigerant and gas refrigerant, which contains noncondensable gas. Moreover, the gas refrigerant containing noncondensable gas accumulates in the upper part space of the receiver 25, and the liquid refrigerant flows out from the lower part of the receiver 25 and is sent to the heat source side expansion valve 26.

In this state, the discharge valve 34c of the separation membrane apparatus 34 opens, and the space S_2 of the separation membrane apparatus 34 transitions to the opened to the atmosphere state. In so doing, the space S_1 is in communication with the upper part of the

receiver 25, and a pressure differential, corresponding to the pressure differential between the atmospheric pressure and the condensing pressure of the refrigerant, consequently arises between the space S_1 and the space S_2. This pressure differential creates a propulsive force, and the noncondensable gas contained in the gas refrigerant remaining in the space S_1 permeates the separation membrane 34b, flows to the space S_2 side, and is released into the atmosphere. However, the gas refrigerant transitions to a state wherein it remains inside the receiver 25, without permeating the separation membrane 34b. When this operation is performed for the prescribed time, the noncondensable gas, remaining in the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7, is discharged from the interior of the refrigerant circuit 10.

In performing the above, the noncondensable gas is discharged from the interior of the refrigerant circuit 10, and the discharge valve 34c of the separation membrane apparatus 34 is subsequently closed.

(3) FEATURES OF THE AIR CONDITIONER, AND ITS METHOD OF CONSTRUCTION

In the present embodiment, the air conditioner 1 and its method of construction have the following features.

(A)

In the air conditioner 1 of the present embodiment, the gas separation apparatus 31 comprising the separation membrane 34b is connected to the liquid side refrigerant circuit 11; therein, the noncondensable gas, such as oxygen gas and nitrogen gas remaining in the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7 after the equipment installing step (the refrigerant circuit constituting step), is separated by a membrane, and can be discharged out of the refrigerant circuit 10; consequently, the size of the gas separation apparatus 31 can be reduced compared with the conventional case that uses a gas separation apparatus that utilizes large amounts of adsorbent. Thereby, the vacuum drawing work can be omitted during construction without increasing the overall size of the refrigeration apparatus (the heat source unit 2 in the present embodiment).

(B)

In the air conditioner 1, the heat source unit 2 and the utilization unit 5 are connected, via the refrigerant connecting pipes 6, 7 in the equipment installing step (the refrigerant circuit constituting step); subsequently, in the noncondensable gas discharging step, the noncondensable gas remaining in the refrigerant connecting pipes 6, 7 is circulated along with the refrigerant inside the refrigerant circuit 10 by operating the compressor 21

(specifically, cooling operation or heating operation), thereby raising the pressure of the refrigerant and the noncondensable gas flowing between the heat source side heat exchanger 23 and the utilization side heat exchanger 51, separating the noncondensable gas from the noncondensable gas-containing refrigerant, whose pressure has been increased, using the gas separation apparatus 31, and discharging the noncondensable gas out of the refrigerant circuit 10. It is possible to improve the separation efficiency of the noncondensable gas in the separation membrane 34b because it is possible to increase the pressure differential between the upstream side (i.e., the space S_1 side) and the downstream side (i.e., the space S_2 side) of the separation membrane 34b of the separation membrane apparatus 34 that constitutes the gas separation apparatus 31.

(C)

In addition, in the air conditioner 1, the size of the gas separation apparatus 31 can be reduced because the gas separation apparatus 31 is connected to the receiver 25 (in the present embodiment, provided integrally with the receiver 25) provided in the liquid side refrigerant circuit 11, the refrigerant flowing in the liquid side refrigerant circuit 11 is gas-liquid separated into liquid refrigerant and noncondensable gas-containing gas refrigerant, the amount of processed gas is reduced, and the gas separation apparatus 31 can subsequently separate and discharge the noncondensable gas.

In addition, the air conditioner 1 further comprises a discharge valve 34c that discharges the noncondensable gas separated by the gas separation apparatus 31, consequently making the vessel, and the like, that accumulates the separated noncondensable gas unnecessary, thereby enabling a further reduction in the size of the gas separation apparatus that performs membrane separation.

(D)

With the method of constructing the air conditioner 1, the seal test of the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7 is performed using the sealed gas, such as nitrogen gas, and the sealed gas is released into the atmosphere; consequently, it is possible after these steps to reduce the amount of oxygen gas remaining inside the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7. Thereby, the amount of oxygen gas circulating together with the refrigerant inside the refrigerant circuit 10 can be reduced, and it is possible to eliminate the risk of problems, such as deterioration in the refrigerant or the refrigerator oil.

(4) MODIFIED EXAMPLE 1

Because the gas separation apparatus 31 of the abovementioned embodiments is provided so that the noncondensable gas is separated from the gas refrigerant in the upper part of the receiver 25, it is possible to separate and eliminate moisture in the gas refrigerant inside the receiver 25 that exists as water vapor, but it is not possible to separate and eliminate the moisture that exists in the liquid refrigerant.

Consequently, as a result of a large amount of moisture unfortunately remaining in the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7 due to, for example, the circumstances in which the piping is constructed, it is possible that a case may arise in which the moisture, along with the noncondensable gas, such as nitrogen gas or oxygen gas, cannot be eliminated from inside the refrigerant circuit 10 to a level that allows operation.

To prevent this, the separation membrane apparatus 34 may be connected to the receiver 25, and a dryer 44 may be connected to the liquid side refrigerant circuit 11, as in a gas separation apparatus 131 incorporated in a heat source unit 102 of an air conditioner 101 of the present modified example depicted in FIG. 4. Furthermore, in FIG. 4, the dryer 44 is connected to the upstream side of the receiver 25, i.e., between the heat source side heat exchanger 23 and the receiver 25, but may also be connected to the downstream side of the receiver 25, i.e., between the receiver 25 and the heat source side expansion valve 26.

Thereby, the noncondensable gas can be separated and discharged, and the moisture remaining inside the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7 can be reliably eliminated from inside the refrigerant circuit 10 to a level that allows operation.

(5) MODIFIED EXAMPLE 2

With the abovementioned gas separation apparatuses 31, 131, the separation membrane apparatus 34 is constituted integrally with the receiver 25; however, the separation membrane apparatus 34 may be connected to the upper part of the receiver 25 via a gas refrigerant introduction circuit 238, as in a gas separation apparatus 231 incorporated in a heat source unit 202 of an air conditioner 201 in the present modified example depicted in FIG. 5 and FIG. 6. Here, the gas refrigerant introduction circuit 238 is a conduit for introducing to the separation membrane apparatus 34 the noncondensable gas-containing gas refrigerant that accumulated in the upper part of the receiver 25, and comprises a gas refrigerant introduction valve 238a for distributing and shutting off the noncondensable gas-containing gas refrigerant introduced to the separation membrane apparatus 34 from the upper part of the receiver 25.

Furthermore, with the gas separation apparatus 231, the operation of discharging the sealed gas, which serves as the noncondensable gas, from inside the refrigerant circuit 10 is performed by the following procedure. First, the gas refrigerant introduction valve 238a is opened, and the noncondensable gas-containing gas refrigerant (supply gas) that accumulated in the upper part of the receiver 25 is introduced to the separation membrane apparatus 34. Then, the discharge valve 34c of the separation membrane apparatus 34 is opened, and the space S_2 of the separation membrane apparatus 34 transitions to the opened to the atmosphere state. In so doing, because the space S_1 of the separation membrane apparatus 34 is in communication with the upper part of the receiver 25, a pressure differential arises between the space S_1 and the space S_2 corresponding to the pressure differential between the atmospheric pressure and the condensing pressure of the refrigerant. Consequently, this pressure differential forms a propulsive force, the noncondensable gas contained in the supply gas inside the space S_1 permeates the separation membrane 34b, flows to the space S_2 side, and is then released into the atmosphere through the discharge valve 34c. However, the gas refrigerant contained in the supply gas transitions to a state where it accumulates inside the space S_1, without permeating the separation membrane 34b. When this operation is executed for the prescribed time, the noncondensable gas remaining in the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7 is discharged from the interior of the refrigerant circuit 10. Then, after the noncondensable gas has been discharged from the interior of the refrigerant circuit 10, the gas refrigerant introduction valve 238a and the discharge valve 34c that constitute the gas separation apparatus 231 are both shut off.

<SECOND EMBODIMENT>

(1) CONSTITUTION OF THE AIR CONDITIONER

FIG. 7 is a schematic view of the refrigerant circuit of an air conditioner 501 as one example of the refrigeration apparatus according to the second embodiment of the present invention. The air conditioner 501 is capable of cooling operation and heating operation in the present embodiment, and comprises a heat source unit 502, the utilization unit 5, and the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7 for connecting the heat source unit 502 and the utilization unit 5. Furthermore, the constitutions of the utilization unit 5 and the refrigerant connecting pipes 6, 7 of the air conditioner 501 in the present embodiment are the same as the utilization unit 5 and the refrigerant connecting pipes 6, 7 of the first embodiment and its modified examples, and their explanations are therefore omitted.

The heat source unit 502 principally comprises the compressor 21, a four-way switching valve 522, the heat source side heat exchanger 23, a bridge circuit 524, a receiver 25, a heat source side expansion valve 26, a liquid side gate valve 27, and a gas side gate valve 28. Namely, the heat source unit 502 of the present embodiment, in addition to the constitution of the heat source units 2, 102, 202 of the first embodiment and its modified examples, comprises the four-way switching valve 522 and the bridge circuit 524, and both the utilization side heat exchanger 51 and the heat source side heat exchanger 23 function as a condenser and an evaporator of the refrigerant. The following explains the four-way switching valve 522 and the bridge circuit 524.

The function of the four-way switching valve 522 is to switch the direction of the refrigerant flow when changing between cooling operation and heating operation; during cooling operation, the discharge side of the compressor 21 and the gas side of the heat source side heat exchanger 23 can be connected, and the intake side of the compressor 21 and the gas side gate valve 28 can be connected. During heating operation, the discharge side of the compressor 21 and the gas side gate valve 28 can be connected, and the intake side of the compressor 21 and the gas side of the heat source side heat exchanger 23 can be connected.

The bridge circuit 524 comprises four check valves 524a – 524d, and is connected between the heat source side heat exchanger 23 and the liquid side gate valve 27. Here, a check valve 524a permits only the distribution of the refrigerant from the heat source side heat exchanger 23 to the receiver 25. A check valve 524b permits only the distribution of the refrigerant from the liquid side gate valve 27 to the receiver 25. A check valve 524c permits only the distribution of the refrigerant from the receiver 25 to the liquid side gate valve 27. A check valve 524d permits only the distribution of the refrigerant from the receiver 25 to the heat source side heat exchanger 23. Thereby, when the refrigerant flows from the heat source side heat exchanger 23 side toward the utilization side heat exchanger 51 side as during cooling operation, the bridge circuit 524 functions so that the refrigerant is flowed through the entrance of and into the receiver 25, and the refrigerant flowing out of the exit of the receiver 25 flows toward the utilization side heat exchanger 51 side after expanding in the heat source side expansion valve 26; additionally, when the refrigerant flows from the utilization side heat exchanger 51 side toward the heat source side heat exchanger 23 side as during heating operation, the bridge circuit 524 functions so that the refrigerant flows through the entrance of and into the receiver 25, and the refrigerant flowing out of the exit of the receiver 25 flows toward the heat source side heat exchanger 23 side after expanding in the heat source side expansion valve 26.

Here, a liquid side refrigerant circuit 511 comprises the refrigerant circuit that ranges from the utilization side heat exchanger 51 to the heat source side heat exchanger 23, including the liquid refrigerant connecting pipe 6, the liquid side gate valve 27, the bridge circuit 524, the receiver 25, and the heat source side expansion valve 26. In addition, a gas side refrigerant circuit 512 comprises the refrigerant circuit ranging from the utilization side heat exchanger 51 to the heat source side heat exchanger 23, including the gas refrigerant connecting pipe 7, the gas side gate valve 28, the four-way switching valve 522, and the compressor 21. In other words, a refrigerant circuit 510 of the air conditioner 501 comprises the liquid side refrigerant circuit 511 and the gas side refrigerant circuit 512.

The air conditioner 501 further comprises the gas separation apparatus 231, which is connected to the liquid side refrigerant circuit 511. The gas separation apparatus 231 is the same as the gas separation apparatus 231 in the modified example of the first embodiment, and its explanation is therefore omitted.

(2) METHOD OF CONSTRUCTING THE AIR CONDITIONER

The following explains the method of constructing the air conditioner 501. Furthermore, excepting the noncondensable gas discharging step, the procedure is the same as the air conditioner 1 constructing method of the first embodiment, and its explanation is therefore omitted.

<NONCONDENSABLE GAS DISCHARGING STEP>

The liquid side gate valve 27 and the gas side gate valve 28 of the heat source unit 502 are opened, after the sealed gas has been released, creating a state wherein the refrigerant circuit of the utilization unit 5 and the refrigerant circuit of the heat source unit 502 are connected. Thereby, the refrigerant that was pre-filled in the heat source unit 502 is supplied to the entire refrigerant circuit 510. However, if the required refrigerant fill quantity is not met with just the amount of refrigerant pre-filled in the heat source unit 502, e.g., if the refrigerant connecting pipes 6, 7 are long, then refrigerant can be externally supplemented and then filled as needed. Furthermore, if the heat source unit 502 is not pre-filled with refrigerant, then the entire amount of the refrigerant needed is externally filled. Thereby, the sealed gas (containing the noncondensable gas remaining in the utilization unit 5 if simultaneously performing the seal test on the utilization unit 5), which serves as the noncondensable gas remaining in the refrigerant connecting pipes 6, 7 after the sealed gas releasing step, is mixed with the refrigerant inside the refrigerant circuit 510.

In this circuit configuration, operation is performed by activating the compressor 21 and circulating the refrigerant inside the refrigerant circuit 510.

(CASE OF DISCHARGING NONCONDENSABLE GAS WHILE PERFORMING COOLING OPERATION)

First, the case of performing the operation that circulates the refrigerant inside the refrigerant circuit 510 by the cooling operation will be explained. At this time, the four-way switching valve 522 is in the state depicted by the solid line in FIG. 7, i.e., the discharge side of the compressor 21 and the gas side of the heat source side heat exchanger 23 are connected, and the intake side of the compressor 21 and the gas side gate valve 28 are connected. In addition, the heat source side expansion valve 26 is in a state wherein its opening is regulated. Furthermore, the gas refrigerant introduction valve 238a and the discharge valve 34c that constitute the gas separation apparatus 231 are both shut off, and the gas separation apparatus 231 is in an unused state.

If the compressor 21 is activated with the refrigerant circuit 510 and the gas separation apparatus 231 in this state, then the gas refrigerant is sucked into and compressed by the compressor 21, sent to the heat source side heat exchanger 23 via the four-way switching valve 522, wherein heat is exchanged with the air or the water that serves as the heat source, and condensed. This condensed liquid refrigerant flows through the check valve 524a of the bridge circuit 524 and into the receiver 25. At this point, the heat source side expansion valve 26 connected to the downstream side of the receiver 25 is in a state wherein its opening is regulated, and the refrigerant pressure ranging from the discharge side of the compressor 21 to the heat source side expansion valve 26 of the liquid side refrigerant circuit 511 rises to the condensing pressure of the refrigerant. Namely, the refrigerant pressure inside the receiver 25 rises to the condensing pressure of the refrigerant. Consequently, the noncondensable gas-containing (specifically, sealed gas) refrigerant in a saturated, gas-liquid mixed phase, remaining in the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7 after releasing the sealed gas, flows into the receiver 25. Furthermore, the refrigerant that flows into the receiver 25 is gas-liquid separated into liquid refrigerant and noncondensable gas-containing gas refrigerant. Moreover, the gas refrigerant containing the noncondensable gas accumulates in the upper part of the receiver 25, and the liquid refrigerant temporarily accumulates inside the receiver 25, subsequently flows out from the lower part of the receiver 25, and is sent to the heat source side expansion valve 26. The liquid refrigerant sent to this heat source side expansion valve 26 expands, transitions to a gas-liquid two-phase state, and is sent to the utilization unit 5 via the check valve 524c of the bridge circuit 524, the liquid side gate valve 27, and the liquid refrigerant connecting pipe 6. Furthermore, the refrigerant sent to the utilization unit 5 evaporates, after it is heat exchanged

with the indoor air by the utilization side heat exchanger 51. This evaporated gas refrigerant once again is sucked into the compressor 21 via the gas refrigerant connecting pipe 7, the gas side gate valve 28, and the four-way switching valve 522.

In this cooling operation state, the operation that discharges the noncondensable gas can be performed the same as the gas separation apparatus 231 of the first embodiment and its modified examples. This procedure is the same as the operation that discharges the noncondensable gas in the gas separation apparatus 231 of the modified example in the first embodiment, and its explanation is therefore omitted.

(CASE OF DISCHARGING NONCONDENSABLE GAS WHILE PERFORMING HEATING OPERATION)

Next, the case of performing the operation that circulates the refrigerant inside the refrigerant circuit 510 by the heating operation will be explained. At this time, the four-way switching valve 522 is in the state depicted by the broken line in FIG. 7, i.e., the discharge side of the compressor 21 and the gas side gate valve 28 are connected, and the intake side of the compressor 21 and the gas side of the heat source side heat exchanger 23 are connected. In addition, the heat source side expansion valve 26 is in a state wherein its opening is regulated. Furthermore, the gas refrigerant introduction valve 238a and the discharge valve 34c that constitute the gas separation apparatus 231 are both shut off, and the gas separation apparatus 231 is in an unused state.

If the compressor 21 is activated with the refrigerant circuit 510 and the gas separation apparatus 231 in this state, then the gas refrigerant is sucked into and compressed by the compressor 21, sent to the utilization unit 5 via the four-way switching valve 522, the gas side gate valve 28, and the gas refrigerant connecting pipe 7. The refrigerant sent to the utilization unit 5 is condensed after it is heat exchanged with the indoor air by the utilization side heat exchanger 51. This condensed liquid refrigerant flows through the liquid refrigerant connecting pipe 6, the liquid side gate valve 27, the check valve 524b of the bridge circuit 524, and into the receiver 25. At this point, the heat source side expansion valve 26 connected to the downstream side of the receiver 25 is in a state wherein its opening is regulated, the same as during cooling operation, and the refrigerant pressure ranging from the discharge side of the compressor 21 to the heat source side expansion valve 26 of the liquid side refrigerant circuit 511 rises to the condensing pressure of the refrigerant. Namely, the refrigerant pressure inside the receiver 25 rises to the condensing pressure of the refrigerant. Consequently, the noncondensable gas-containing (specifically, sealed gas) refrigerant in a saturated, gas-liquid mixed phase, remaining in the liquid refrigerant connecting pipe 6 and

the gas refrigerant connecting pipe 7 after releasing the sealed gas, flows into the receiver 25, the same as during cooling operation. Furthermore, the refrigerant that flows into the receiver 25 is gas-liquid separated into liquid refrigerant and noncondensable gas-containing gas refrigerant. Moreover, the gas refrigerant containing the noncondensable gas accumulates in the upper part of the receiver 25, and the liquid refrigerant temporarily accumulates inside the receiver 25, subsequently flows out from the lower part of the receiver 25, and is sent to the heat source side expansion valve 26. The liquid refrigerant sent to this heat source side expansion valve 26 expands, transitions to a gas-liquid two-phase state, and is sent to the heat source side heat exchanger 23 via the check valve 524d of the bridge circuit 524. Furthermore, the refrigerant sent to the heat source side heat exchanger 23 evaporates, after it is heat exchanged with air or water serving as the heat source. This evaporated gas refrigerant once again is sucked into the compressor 21 via the four-way switching valve 522.

In this heating operation state as well, the operation that discharges the noncondensable gas can be performed the same as in the cooling operation state. This procedure is the same as the abovementioned operation that discharges noncondensable gas in the cooling operation state, i.e., the operation that discharges the noncondensable gas in the gas separation apparatus 231 of the modified example in the first embodiment, and its explanation is therefore omitted.

Thus, in the air conditioner 501 of the present embodiment, the operation that discharges the noncondensable gas remaining in the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7 from inside the refrigerant circuit 510 can be performed using the gas separation apparatus 231 by circulating the refrigerant inside the refrigerant circuit 510, the same as the first embodiment and its modified examples.

(3) MODIFIED EXAMPLE 1

With the abovementioned gas separation apparatus 231, the receiver 25 and the separation membrane apparatus 34 are connected via the gas refrigerant introduction circuit 238, but may be integrally constituted, as in the gas separation apparatus 31 incorporated in a heat source unit 602 of an air conditioner 601 in the present modified example depicted in FIG. 8, the same as the gas separation apparatus 31 in the first embodiment.

(4) ANOTHER MODIFIED EXAMPLE

In the air conditioners 501, 601 comprising the abovementioned gas separation apparatuses 31, 231, a dryer may be connected to the liquid side refrigerant circuit 511 to eliminate moisture remaining in the refrigerant circuit 510, the same as the air conditioner 101 in the modified example of the first embodiment.

<THIRD EMBODIMENT>

(1) CONSTITUTION OF THE AIR CONDITIONER

FIG. 9 is a schematic view of a refrigerant circuit of an air conditioner 1001 as one example of a refrigeration apparatus according to the third embodiment of the present invention. In the present embodiment, the air conditioner 1001 is capable of cooling operation and heating operation, the same as the air conditioner 501 of the second embodiment, and comprises a heat source unit 1002, the utilization unit 5, and the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7 for connecting the heat source unit 1002 and the utilization unit 5. Furthermore, excepting a gas separation apparatus 1031 of the present embodiment, the constitution of the air conditioner 1001 is the same as the air conditioner 501 of the second embodiment, and its explanation is therefore omitted.

In the present embodiment, the gas separation apparatus 1031 principally comprises a separation membrane apparatus 1034.

The separation membrane apparatus 1034 separates the noncondensable gas from the noncondensable gas-containing gas refrigerant that accumulated in the upper part of the receiver 25, and discharges the separated noncondensable gas out of the refrigerant circuit 510, the same as the separation membrane apparatus 34 of the first and second embodiments. The separation membrane apparatus 1034 is connected to the receiver 25 via the gas refrigerant introduction circuit 238. In the present embodiment, the separation membrane apparatus 1034 comprises, as depicted in FIG. 10, an apparatus main body 1034a, a separation membrane 1034b disposed so that it partitions the space inside the apparatus main body 1034a into a space S_3 (upstream side) and a space S_4 (downstream side) in communication with the gas refrigerant introduction circuit 238, a discharge valve 1034c connected to the space S_3, and a gas refrigerant outflow circuit 1041 connected to the space S_4. In the present embodiment, the separation membrane 1034b uses a membrane capable of selectively permeating gas refrigerant from the noncondensable gas-containing gas refrigerant. A nonporous membrane made of polysulfone membrane, silicone rubber membrane, and the like, is used for such a separation membrane. Here, the nonporous membrane is a homogenous membrane that does not have numerous extremely fine pores like a porous membrane, and the gas separates due to the speed differential when permeating the inside of the membrane through the processes of dissolving, diffusing, and de-dissolving; in other words, components having a high boiling point and that are highly soluble in the membrane permeate, while components having a low boiling point and that are poorly soluble in the membrane do not permeate. Here, because the boiling points of the R22 and

R134a used as the refrigerant in the air conditioner, and the R32 and the R125 contained in the mixed refrigerants R407c and R410a, are all higher than the boiling points of water vapor, oxygen gas, and nitrogen gas, they can be separated by this nonporous membrane. Thereby, the separation membrane 1034b can selectively permeate the gas refrigerant from the noncondensable gas-containing gas refrigerant (specifically, the supply gas, which is a gaseous mixture of the noncondensable gas and the gas refrigerant accumulated in the upper part of the receiver 25), thereby causing the gas refrigerant to flow from the space S_3 into the space S_4. The gas refrigerant outflow circuit 1041 is provided so that the space S_4 of the separation membrane apparatus 1034 and the intake side of the compressor 21 are connected, and comprises a gas refrigerant return valve 1041a that distributes and shuts off the gas refrigerant that permeates the separation membrane 1034b and returns into the refrigerant circuit 510. Here, the gas refrigerant outflow circuit 1041 is provided so that the gas refrigerant returns to the intake side of the compressor 21, which has the lowest refrigerant pressure inside the refrigerant circuit 510, and the pressure differential between the space S_3 and the space S_4 can thereby be increased. The discharge valve 1034c can release the noncondensable gas, remaining inside the space S_3, into the atmosphere by causing the gas refrigerant to permeate the separation membrane 1034b, and can thereby discharge the noncondensable gas out of the refrigerant circuit 510.

(2) METHOD OF CONSTRUCTING THE AIR CONDITIONER

The following explains the method of constructing the air conditioner 1001. Furthermore, excepting the noncondensable gas discharging step, the procedure is the same as the air conditioner 1 constructing method of the first embodiment, and its explanation is therefore omitted.

<NONCONDENSABLE GAS DISCHARGING STEP>

After the sealed gas has been released, the liquid side gate valve 27 and the gas side gate valve 28 of the heat source unit 1002 are opened, creating a state wherein the refrigerant circuit of the utilization unit 5 and the refrigerant circuit of the heat source unit 1002 are connected. Thereby, the refrigerant that was pre-filled in the heat source unit 1002 is supplied to the entire refrigerant circuit 510. However, if the required refrigerant fill quantity is not met just with the amount of refrigerant pre-filled in the heat source unit 1002, e.g., if the refrigerant connecting pipes 6, 7 are long, then refrigerant can be externally supplemented and then filled as needed. Furthermore, if the heat source unit 1002 is not pre-filled with refrigerant, then the entire amount of the refrigerant needed is externally filled. Thereby, the sealed gas (containing the noncondensable gas remaining in the utilization unit 5 if

simultaneously performing the seal test on the utilization unit 5), which serves as the noncondensable gas remaining in the refrigerant connecting pipes 6, 7 after the sealed gas releasing step, is mixed with the refrigerant inside the refrigerant circuit 510.

In this circuit configuration, operation is performed by activating the compressor 21 and circulating the refrigerant inside the refrigerant circuit 510.

(CASE OF DISCHARGING NONCONDENSABLE GAS WHILE PERFORMING COOLING OPERATION)

First, the case of performing the operation that circulates the refrigerant inside the refrigerant circuit 510 by the cooling operation will be explained. At this time, the four-way switching valve 522 is in the state depicted by the solid line in FIG. 9, i.e., the discharge side of the compressor 21 and the gas side of the heat source side heat exchanger 23 are connected, and the intake side of the compressor 21 and the gas side gate valve 28 are connected. In addition, the heat source side expansion valve 26 is in a state wherein its opening is regulated. Furthermore, the gas refrigerant introduction valve 238a, the gas refrigerant return valve 1041a, and the discharge valve 1034c that constitute the gas separation apparatus 1031 are all shut off, and the gas separation apparatus 1031 is in an unused state.

If the compressor 21 is activated with the refrigerant circuit 510 and the gas separation apparatus 1031 in this state, then cooling operation is performed the same as in the second embodiment. Furthermore, the operation of the refrigerant circuit 510 is the same as in the second embodiment, and its explanation is therefore omitted.

The following explains the operation of discharging the noncondensable gas from inside the refrigerant circuit 510 using the gas separation apparatus 1031. First, the gas refrigerant introduction valve 238a is opened, and the noncondensable gas-containing gas refrigerant (supply gas) that accumulated in the upper part of the receiver 25 is introduced inside the separation membrane apparatus 1034. Subsequently, the gas refrigerant return valve 1041a of the separation membrane apparatus 1034 is opened, and the refrigerant pressure inside the space S_4 of the separation membrane apparatus 1034 reaches a pressure the same as the pressure of the refrigerant flowing on the intake side of the compressor 21. In so doing, the space S_3 of the separation membrane apparatus 1034 is in communication with the upper part of the receiver 25, and a pressure differential consequently arises between the space S_3 and the space S_4 that corresponds to the pressure differential between the condensing pressure of the refrigerant and the pressure on the intake side of the compressor 21. Consequently, this pressure differential forms a propulsive force, and the gas refrigerant

contained in the supply gas that accumulated inside the space S_3 permeates the separation membrane 1034b, flows to the space S_4 side, and returns to the intake side of the compressor 21 through the gas refrigerant return valve 1041a. However, the noncondensable gas (nonpermeating gas), remaining inside the space S_3 due to the gas refrigerant permeating the separation membrane 1034b and flowing to the space S_4 side, is released into the atmosphere by the opening of the discharge valve 1034c. If this operation is executed for the prescribed time, then the noncondensable gas remaining in the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7 is discharged from inside the refrigerant circuit 510.

Furthermore, after the noncondensable gas is discharged from inside the refrigerant circuit 510, the gas refrigerant introduction valve 238a, the gas refrigerant return valve 1041a, and the discharge valve 1034c that constitute the gas separation apparatus 1031 are all turned off.

(CASE OF DISCHARGING NONCONDENSABLE GAS WHILE PERFORMING HEATING OPERATION)

The following explains the case wherein the operation that circulates the refrigerant inside the refrigerant circuit 510 is performed by the heating operation. At this time, the four-way switching valve 522 is in the state depicted by the broken line in FIG. 9, i.e., in a state wherein the discharge side of the compressor 21 is connected to the gas side gate valve 28, and the intake side of the compressor 21 is connected to the gas side of the heat source side heat exchanger 23. In addition, the heat source side expansion valve 26 is in a state in which its opening is regulated. Furthermore, the gas refrigerant introduction valve 238a, the gas refrigerant return valve 1041a, and the discharge valve 1034c that constitute the gas separation apparatus 1031 are all shut off, and the gas separation apparatus 1031 is in an unused state.

If the compressor 21 is activated with the refrigerant circuit 510 and the gas separation apparatus 1031 in this state, the same heating operation as in the second embodiment is performed. Furthermore, the operation of the refrigerant circuit 510 and the gas separation apparatus 1031 is the same as the operation to discharge the noncondensable gas in the cooling operation state, and its explanation is therefore omitted.

(3) FEATURES OF THE AIR CONDITIONER, AND THE CONSTRUCTING METHOD THEREOF

The air conditioner 1001 of the present embodiment differs from the constitution of the air conditioners 1, 101, 201, 501, 601 of the first and second embodiments in that a nonporous membrane is employed as the separation membrane 1034b, which constitutes the

separation membrane apparatus 1034, that selectively permeates the refrigerant, but otherwise has the same features as the air conditioners 1, 101,201, 501, 601 and their constructing methods in the first and second embodiments.

(4) MODIFIED EXAMPLE 1

The abovementioned gas separation apparatus 1031 is constituted so that the gas refrigerant separated in the separation membrane apparatus 1034 is returned to the intake side of the compressor 21 via the gas refrigerant outflow circuit 1041, but may be provided so that a gas refrigerant outflow circuit 1141 is connected between the separation membrane apparatus 1034 and the heat source side expansion valve 26 downstream side (specifically, between the downstream side of the heat source side expansion valve 26 and the check valves 524c, 524d of the bridge circuit 524), as in a gas separation apparatus 1131 incorporated in a heat source unit 1102 of an air conditioner 1101 of the present modified example depicted in FIG. 11.

(5) MODIFIED EXAMPLE 2

With the abovementioned gas separation apparatuses 1031, 1131, the receiver 25 and the separation membrane apparatus 1034 are connected via a gas refrigerant introduction circuit 238, but the receiver 25 and the separation membrane apparatus 1034 may be constituted integrally, as in a gas separation apparatus 1231 incorporated in a heat source unit 1202 of an air conditioner 1201 of the present modified example depicted in FIG. 12, the same as the gas separation apparatus 31 in the first embodiment. At this time, the upper part space (i.e., the space on the upstream side of the separation membrane 34b) of the receiver 25 is connected to the discharge valve 1034c, and the space on the downstream side of the separation membrane 1034b is connected to the gas refrigerant outflow circuit 1041.

(6) ANOTHER MODIFIED EXAMPLE

In the abovementioned gas separation apparatus 1131, the receiver 25 and the separation membrane apparatus 1034 may be integrally constituted, as in the gas separation apparatus 1231.

In addition, in the air conditioners 1, 101, 201, 501, 601 of the first embodiment and its modified examples, the separation membrane apparatus 1034 of the present embodiment and its modified examples may be employed as the separation membrane apparatus that constitutes the gas separation apparatus.

Furthermore, in the air conditioners 1001, 1101, 1201 comprising the abovementioned gas separation apparatuses 1031, 1131, 1231, the dryer for eliminating the moisture

remaining in the refrigerant circuit 510 may be connected to the liquid side refrigerant circuit 511, the same as in the air conditioner 101 in the modified example of the first embodiment.

<FOURTH EMBODIMENT>

(1) CONSTITUTION AND FEATURES OF THE AIR CONDITIONER

FIG. 13 is a schematic view of the refrigerant circuit of an air conditioner 1501 as one example of the refrigeration apparatus according to the fourth embodiment of the present invention. The air conditioner 1501 is a so-called multitype air conditioner capable of cooling operation and heating operation, and comprises a heat source unit 1502, a plurality (in the present embodiment, two units) of utilization units 1505, and a liquid refrigerant connecting pipe 1506 and a gas refrigerant connecting pipe 1507 that connect the heat source unit 1502 and the plurality of utilization units 1505.

Each utilization unit 1505 principally comprises the utilization side heat exchanger 51 and a utilization side expansion valve 1552. Here, the utilization side heat exchanger 51 is the same as the utilization side heat exchanger 51 of the air conditioner 501 of the second embodiment, and its explanation is therefore omitted.

Each utilization side expansion valve 1552 is connected to the liquid side of the respective utilization side heat exchanger 51 in order to regulate the refrigerant pressure, the refrigerant flow, and the like. In the present embodiment, each utilization side expansion valve 1552 has a function that expands the refrigerant, particularly during cooling operation.

The heat source unit 1502 principally comprises the compressor 21, the four-way switching valve 522, the heat source side heat exchanger 23, a bridge circuit 1524, the receiver 25, a heat source side expansion valve 1526, the liquid side gate valve 27, and the gas side gate valve 28. Here, the compressor 21, the four-way switching valve 522, the heat source side heat exchanger 23, the receiver 25, the liquid side gate valve 27, and the gas side gate valve 28 are the same as the compressor 21, the four-way switching valve 522, the heat source side heat exchanger 23, the receiver 25, the liquid side gate valve 27, and the gas side gate valve 28 of the air conditioner 501 of the second embodiment, and their explanations are therefore omitted.

In the present embodiment, the bridge circuit 1524 comprises three check valves 524a – 524c and the heat source side expansion valve 1526, and is connected between the heat source side heat exchanger 23 and the liquid side gate valve 27. Here, a check valve 524a permits only the distribution of the refrigerant from the heat source side heat exchanger 23 to the receiver 25. A check valve 524b permits only the distribution of the refrigerant from the liquid side gate valve 27 to the receiver 25. A check valve 524c permits only the distribution

of the refrigerant from the receiver 25 to the liquid side gate valve 27. The heat source side expansion valve 1526 is connected between the exit of the receiver 25 and the heat source side heat exchanger 23 to regulate the refrigerant pressure, the refrigerant flow, and the like. In the present embodiment, during cooling operation, the heat source side expansion valve 1526 is fully closed and functions so that the refrigerant flowing from the heat source side heat exchanger 23 toward the utilization side heat exchanger 51 flows via the entrance of and into the receiver 25; during heating operation, its opening is regulated, and it functions so that the refrigerant flowing from the utilization side heat exchanger 51 (specifically, the exit of the receiver 25) toward the heat source side heat exchanger 23 is expanded. Thereby, when the refrigerant flows from the heat source side heat exchanger 23 side toward the utilization side heat exchanger 51 side as during cooling operation, the bridge circuit 1524 functions so that the refrigerant is flowed through the entrance of and into the receiver 25, and the refrigerant flowing out of the exit of the receiver 25 is distributed to the utilization side heat exchanger 51 side without expanding in the heat source side expansion valve 1526; additionally, when the refrigerant flows from the utilization side heat exchanger 51 side toward the heat source side heat exchanger 23 side as during heating operation, the bridge circuit 1524 functions so that the refrigerant flows through the entrance of and into the receiver 25, and the refrigerant flowing out of the exit of the receiver 25 is distributed to the heat source side heat exchanger 23 side after expanding in the heat source side expansion valve 1526.

The liquid refrigerant connecting pipe 1506 is connected between the liquid side of the utilization side heat exchanger 51 of each of the plurality of utilization units 1505 and the liquid side gate valve 27 of the heat source unit 1502. The gas refrigerant connecting pipe 1507 is connected between the gas side of the utilization side heat exchanger 51 of each of the plurality of utilization units 1505 and the gas side gate valve 28 of the heat source unit 1502. The liquid refrigerant connecting pipe 1506 and the gas refrigerant connecting pipe 1507 are the refrigerant connecting pipes constructed on site when newly constructing the air conditioner 1501, or the refrigerant connecting pipes diverted from an existing air conditioner when replacing any one or both of the heat source unit 1502 and the utilization units 1505.

Here, a liquid side refrigerant circuit 1511 comprises the refrigerant circuit that ranges from the utilization side heat exchanger 51 to the heat source side heat exchanger 23, including the liquid refrigerant connecting pipe 1506, the liquid side gate valve 27, the bridge circuit 1524, the receiver 25, and the heat source side expansion valve 1526. In addition, a gas side refrigerant circuit 1512 comprises the refrigerant circuit ranging from the utilization side heat exchanger 51 to the heat source side heat exchanger 23, including the gas refrigerant

connecting pipe 1507, the gas side gate valve 28, the four-way switching valve 522, and the compressor 21. In other words, a refrigerant circuit 1510 of the air conditioner 1501 comprises the liquid side refrigerant circuit 1511 and the gas side refrigerant circuit 1512.

The air conditioner 1501 further comprises the gas separation apparatus 231, which is connected to the liquid side refrigerant circuit 1511. The gas separation apparatus 231 can separate from the refrigerant and discharge out of the refrigerant circuit 1510 the noncondensable gas, remaining in the liquid refrigerant connecting pipe 1506 and the gas refrigerant connecting pipe 1507, by operating the compressor 21 and circulating the refrigerant in the refrigerant circuit 1510, and is built into the heat source unit 1502 in the present embodiment. Here, the gas separation apparatus 231 is the same as the gas separation apparatus 231 of the air conditioner 201 in the modified example of the first embodiment, and its explanation is therefore omitted.

In the air conditioner 1501 of this type as well, the operation that discharges the noncondensable gas remaining in the liquid refrigerant connecting pipe 1506 and the gas refrigerant connecting pipe 1507 from inside the refrigerant circuit 1510 can be performed using the gas separation apparatus 231 by using a method of construction the same as the air conditioner 501 of the second embodiment and circulating the refrigerant inside the refrigerant circuit 1510.

In particular, in the case of a multitype air conditioner, as in the air conditioner 1501 of the present embodiment, the length and diameter of each of the refrigerant connecting pipes 1506, 1507 is larger than the refrigerant connecting pipes of the comparatively compact air conditioner, as in a room air conditioner, and the amount of noncondensable gas that must be discharged from inside the refrigerant circuit 1510 is large; consequently, this method of construction is useful.

(2) MODIFIED EXAMPLE

The receiver 25 and the separation membrane apparatus 34 may be integrally constituted, as in the gas separation apparatus 31 according to the first and second embodiments.

In addition, the gas separation apparatuses 1031, 1131, 1231 each comprising a separation membrane 1034b made of a nonporous membrane, according to the third embodiment and its modified examples, may be used as the gas separation apparatus.

<ANOTHER EMBODIMENT>

The above explained the embodiments of the present invention, referencing the drawings, but the specific constitution is not limited to these embodiments, and it is

understood that variations and modifications may be effected without departing from the spirit and scope of the invention.

For example, in the abovementioned embodiments, the present invention was applied to an air conditioner capable of operation by switching between cooling and heating operation, an air conditioner dedicated to cooling operation, and a multitype air conditioner with a plurality of utilization units connected thereto; however, the present invention is not limited thereto, and may also be applied to an ice thermal storage type air conditioner, other separate type refrigeration apparatusses, and the like.

<INDUSTRIAL FIELD OF APPLICATION>

Using the present invention can improve the efficiency of separating a noncondensable gas with a separation membrane in a refrigeration apparatus constituted, for the purpose of omitting the vacuum drawing work, so that, by using a separation membrane, it can separate and eliminate the noncondensable gas, in a state mixed with a refrigerant inside a refrigerant circuit, that was left inside the refrigerant connecting pipe during on-site construction.